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STUDIES FOR STUDENTS

A CLASSIFICATION OF COMMON SEDIMENTS AND SOME CRITERIA FOR IDENTIFICATION OF THE VARIOUS CLASSES

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Sedimentary rocks are useful to the geologist chiefly through the record of the history of the earth which they contain, and it is desirable that classifications of these rocks should be so arranged as to bring out as much of that history as possible. The common classification of sedimentary rocks, on the basis of texture and mineral composition, into conglomerates, sandstones, shales, and limestones is hardly adequate, because the origin of the rock is only slightly implied, if at all, in the definition. For instance, under the present classification, sandstone is sand cemented; but the discovery of sandstone in a locality may record either a shallow sea not far from shore, dry, windy conditions and the piling-up of sand by wind, the previous existence of lakes receiving sand from near-by lands, or fluvial conditions under which the sand was deposited by streams. Similarly, conglomerate may be marine, fluvial, pluvial, glacial, or lacustrine in its origin. Even limestone is being laid in inland lakes today, as well as in the sea, and by wind in the Bermuda Islands.

If sedimentary rocks are to perform their function as true recorders of past events, their classification must be based on the origin of those rocks. The agents and processes by which sedimentary rocks are made lie chiefly in the realm of physiographic geology. This paper places a physiographic interpretation on the origin of sedimentary rocks.

It is of course understood that there is a wide gap between sediments and sedimentary rocks, but it is also believed that a classification of the various sorts of sediments will be at least a step toward a more effective classification of sedimentary rocks, and that many of the criteria for distinguishing various sorts of sediments are also applicable to rocks resulting from sediments after cementation.

The classification and lists of characters which follow are not presented with the idea that they contain matter which is new, but merely to bring together, in a way intended to be helpful, certain things which have been well known to geologists. Much of it has been published in one place and another in standard works, and these sources have been drawn upon freely in the preparation of the present paper.

The various sorts of common sediments are as follows:

- Eolian
- Fluvial
- Pluvial
- Talus
- Glacial
  - *a*) Till
  - *b*) Fluvio-glacial deposits
- Lacustrine
  - *a*) Near-shore phase
  - *b*) Still-water phase
- Marine
  - *a*) Shallow-water deposits
    - (1) Zone of major agitation
    - (2) Zone of minor agitation
  - *b*) Deep-water deposits

By pluvial deposits are meant those transported by rain water or immediate run-off, without the agency of permanent streams. Talus deposits are those whose constituents are rolled down steep slopes by the action of gravity, not necessarily aided by water. Near-shore lacustrine deposits are those laid in lakes between high-water mark and the surf line. Shallow-water marine deposits are those laid in the sea between high-water mark and the 100-fathom line, and deep-water deposits are laid in the deep sea beyond the 100-fathom line. The shallow-water deposits of the sea have been generally divided into (*a*) littoral deposits (those laid between high- and low-water marks) and (*b*) non-littoral deposits (between low-water mark and the 100-fathom line).[1] For present purposes at least this is not a happy division, for after analysis it is clear that the differences between deposits above low-water mark and those below low-water mark are slight, and that the differences between deposits in greatly agitated waters and those in quieter waters are great. In spite of infelicities of expression, it seems best here to divide the shallow-water deposits of the sea into two groups, (*a*) those of the zone of major agitation, and (*b*) those of the zone of minor agitation. The deposits of the zone of major agitation include beach deposits, bars, spits, hooks, barrier reefs, etc., for the most part materials laid within the surf line, and the deposits of minor agitation are those laid in quieter water in general beyond the surf line. None of the other terms needs definition here.

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[1] See Murray, *Report of the H.M.S. Challenger, Deep Sea Deposits*, p. 186; and Chamberlin and Salisbury, *Geology*, I, 368, 369, and 379.

The lists of characters of these various sorts of deposits, given below, are the results of (1) a study of the processes and agents by which they are deposited, and (2) observation of undoubted types of the various sorts of deposits in the field. Sand dunes have been studied at the south end of Lake Michigan and loess in Iowa, Illinois, and Wisconsin. Fluvial deposits were examined particularly in Owens Valley, California. Pluvial deposits were noted in Owens Valley, and in the southern Appalachians; talus slopes in Wisconsin, California, and Wyoming; glacial materials in Wisconsin and Illinois; lacustrine deposits in extinct lake bottoms in Wisconsin, and in the Pliocene lake deposits of the Inyo Mountains; and marine deposits in the Paleozoic rocks of the Mississippi Valley.

CHARACTERS OF EOLIAN DEPOSITS

Eolian deposits have the following characteristics. For the sake of brevity they are listed.

1. Low textural range.
2. Material all finely divided.
3. Sorted into irregular beds and lenses.
4. Stratification-planes dip in all directions.
5. Stratification-planes have dips varying in amount up to 30°±.
6. Material porous.
7. Distributed in irregular areas, not continuous.
8. Vary greatly in thickness within short distances.
9. May be ripple-marked.
10. Grains of sand are rounded.
11. Fossils, if any, are of terrestrial forms.

Most of the foregoing statements need no explanation. No. 4 is due to the constant shifting of the wind and to the irregular surfaces on which dust and sand are laid. In No. 5, the 30° dip is the angle of the lee-sides of sand dunes, as read with the clinometer, and is the angle of rest for sand. These are the characters of eolian sand, but, with the possible exception of 5, 7, 9, and 10, they also characterize loess. A typical section of dune sand is shown in Fig. 1.

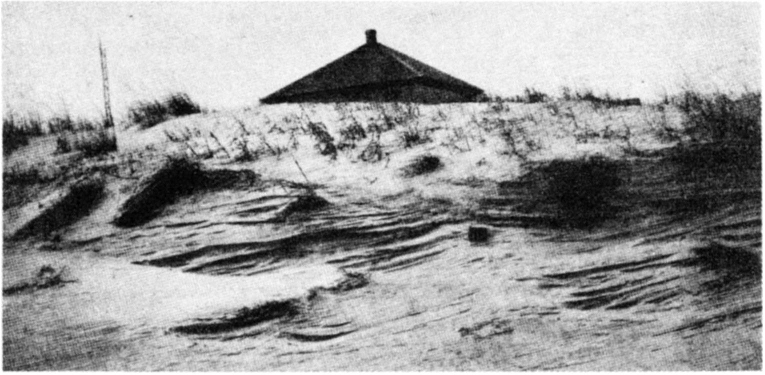

FIG. 1.—A section of sand deposited by the wind near Cape Henry, Virginia (photograph by Dr. T. W. Vaughan).

CHARACTERS OF FLUVIAL DEPOSITS

The conditions under which streams deposit are so various that it is difficult and perhaps unwise to list any one set of characters which will fit all fluvial materials. Swift streams deposit their coarse loads at the bases of mountains under conditions quite different from those of larger and sluggish streams depositing on their flood plains, and yet both distribute, both flow in one general direction, both sort their materials at least roughly, and, after all, the results differ chiefly in degree rather than in principle. Fluvial deposits have the following characteristics:

1. Relatively fine material, though some fans include large bowlders.
2. High textural range (fans), and low textural range (some flood-plain deposits).
3. Only roughly sorted.
4. Lens and pocket structure.

5. Distributed in belts (river flats and piedmont alluvial plains).
6. Bedding planes dip in one general direction, though slightly divergent in the direction of general dip.
7. Beds dip at angles varying up to 18°±.
8. Deposit diminishes uniformly in thickness in the direction of the divergence of dips.
9. Material likely to be heterogeneous, lithologically.
10. Pieces angular or rounded.
11. Fossils rare, and of terrestrial forms.

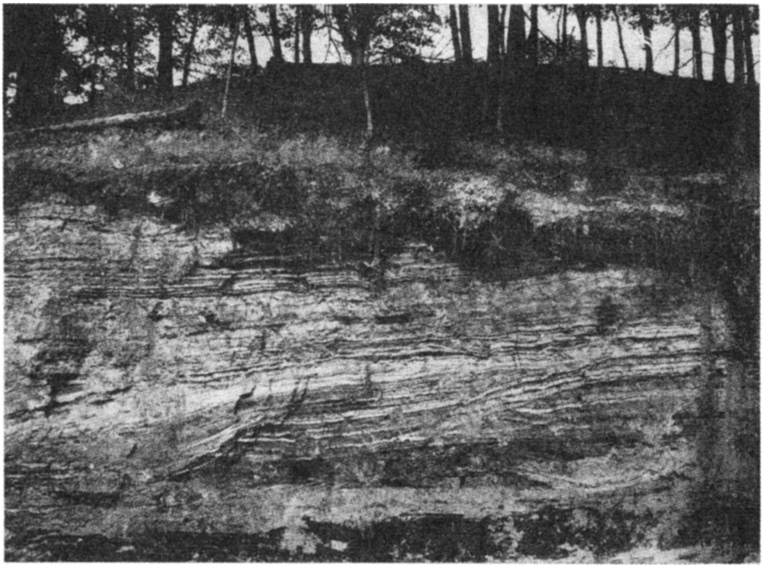

FIG. 2.—A typical fluvial deposit, showing lens and pocket structure. A section of a stream terrace in Jo Daviess County, Ill.

The lens and pocket structure seems to be especially characteristic of fluvial deposits. In Owens Valley no textural division in the fans could be traced more than fifty feet in any direction. This structure is quite unlike the layered character of still-water deposits such as those laid in lakes or in the sea, and somewhat different from the structure of materials deposited by ocean or lake waves and currents. The 18° of No. 7 above is the highest angle read on the surface of the fans. The slight divergence of dips as stated in No. 6 is due to distribution of the streams. Fig. 2

shows a fluvial deposit of one type in a stream terrace in northwestern Illinois. Lens and pocket structure is visible here. A somewhat different type is shown in Fig. 3, this being a photograph of a section of an alluvial fan at the foot of the Sierra Nevada Mountains in California. While these two deposits are quite different, the differences are those of degree rather than of principle.

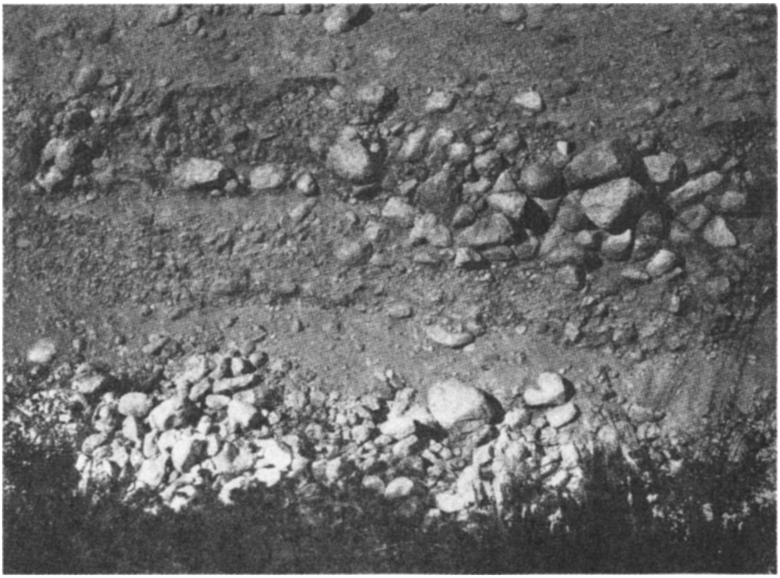

FIG. 3.—A fluvial deposit at the foot of the Sierra Nevada Mountains in California.

CHARACTERS OF PLUVIAL DEPOSITS

Pluvial deposits are similar to those deposited under fluvial conditions, except that (1) the material is not so well sorted, (2) it is more restricted in distribution, (3) the beds, if any, dip at higher angles, (4) the material is more likely to be homogeneous lithologically, for it has not been transported so far from the parent ledges, and (5), because not transported so far, the constituent pieces are likely to be more angular. For the sake of easy reference, the list of characters follows:

1. Material coarse.
2. High textural range.

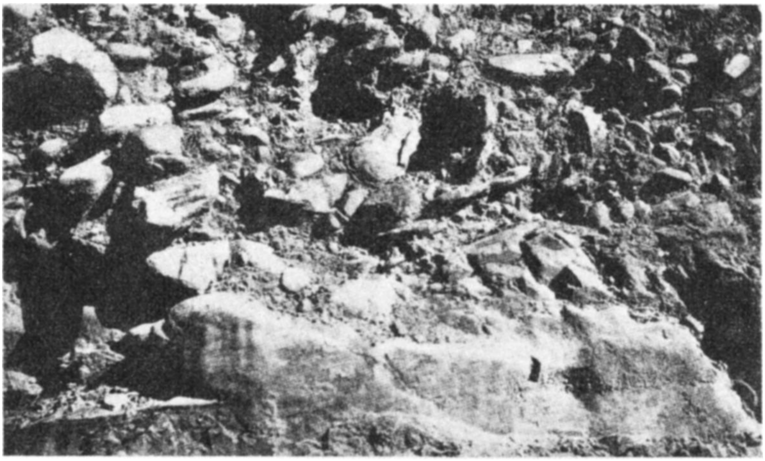

FIG. 4.—A pluvial deposit in North Carolina.

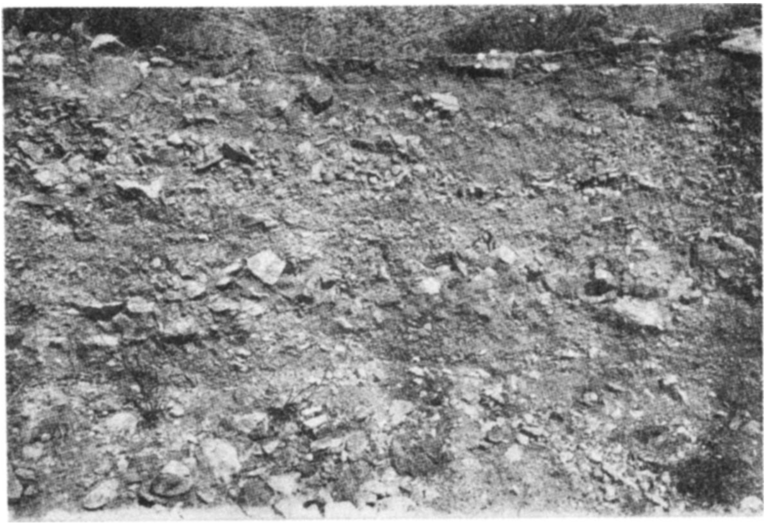

FIG. 5.—A pluvial deposit at the foot of the Inyo Mountains in California. The crude sorting and the angularity of the pieces are the features of the section.

3. Very crude sorting.
4. Distributed in restricted areas, on or near steep slopes.
5. Beds, if any are visible, dip in one general direction, though diverging.
6. Beds, if any, may dip at high angles.
7. Deposit varies in thickness, decreasing uniformly in direction of divergence of dips.
8. Material local and homogeneous lithologically.
9. Pieces, angular.
10. Fossils, if any, of terrestrial forms.
11. Surface and base of formation may have steep slopes.

Figs. 4 and 5 show types of pluvial deposits, one in North Carolina and the other at the foot of the Inyo Mountains in California.

CHARACTERS OF TALUS DEPOSITS

Talus deposits are not abundant among sedimentary materials, and yet they exist. At Ableman, Wis., a talus slope of Huronian quartzite is included in Potsdam sandstone, and it is possible that other conglomerates belong to this type of deposits. The characters of these deposits are listed below. Fig. 6 shows a talus slope of quartzite at Devils Lake, Wis.

1. Coarse material greatly predominates over fine.
2. Pieces are the result of mechanical disintegration.
3. Pieces angular.
4. No stratification.
5. Distributed in restricted and isolated areas, or in very narrow belts near high lands.
6. Base and surface of formation have steep slopes.
7. Pieces touch one another.
8. Very porous.

CHARACTERS OF GLACIAL TILL

The characters of glacial till are so well known as to need no discussion here. For the sake of getting the criteria together the list is given.

1. Heterogeneous in composition.
2. High textural range (rock flour to enormous bowlders).
3. Coarse material generally subordinate in amount to fine.
4. No stratification.
5. Constituents, largely subangular.
6. Great variation in thickness within short distances.

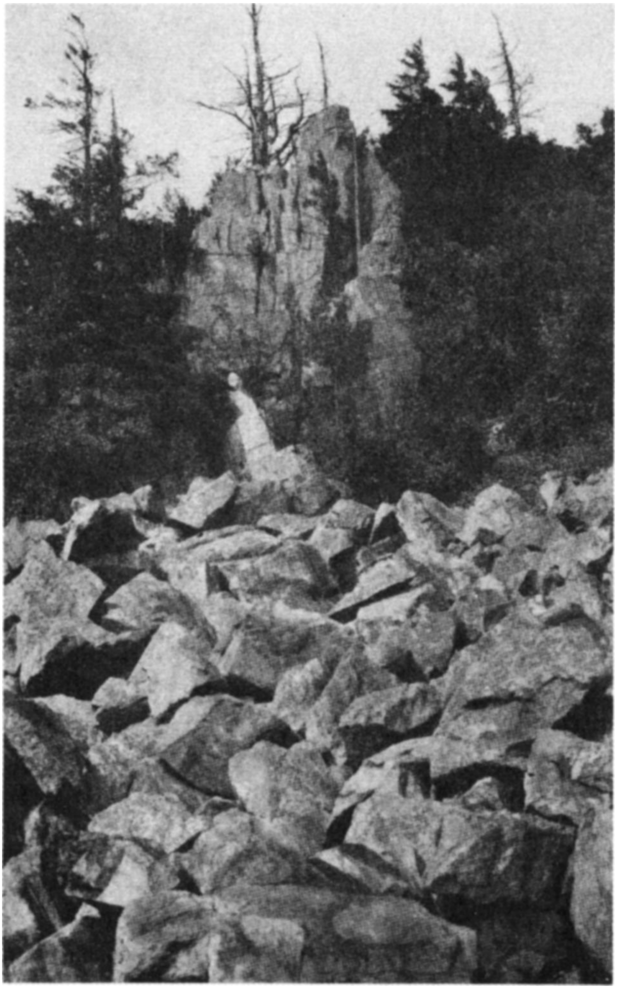

FIG. 6.—A talus slope of blocks of quartzite at Devils Lake, Wis. (photograph by J. J. Runner).

7. Appreciable part of material foreign to location in which deposit is found (does not hold for all glacial deposits in high mountains).
8. Some of the stony matter striated.
9. Lies on unweathered bed (in general).
10. Sharp plane between drift and underlying formation.
11. Beds striated, grooved, bruised, etc.
12. Fossils, if any, show evidences of wear by transportation.

This type of deposit is illustrated in Fig. 7.

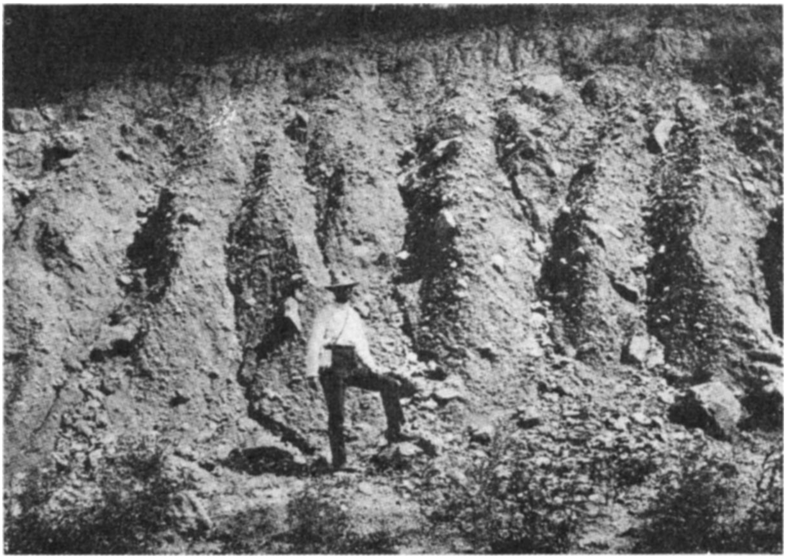

FIG. 7.—A section of glacial till in Wisconsin.

CHARACTERS OF FLUVIO-GLACIAL DEPOSITS

Corresponding with the characters of the depositing agents, fluvio-glacial deposits are closely allied to fluvial deposits on the one hand and to glacial till on the other; in general they resemble the former in texture and the latter in lithologic constitution. In shape the constituents of these deposits are a combination of form due to glacial wear and that given to pieces rolled along the bottoms of streams. The list follows:

1. Heterogeneous in constitution.
2. Moderate textural range.
3. All material stratified.

4. Sorted into lenses and pockets rather than into definite, uniform, continuous layers.

5. Constituents have a roundness superimposed on subangularity.

6. Striae rare or lacking on pebbles.

7. Thickness varies with irregularities in bed and shows a general tendency to thin in one direction.

8. Appreciable part of material foreign.

9. Generally does not lie on bed rock, and contact below is not necessarily sharp.

10. Fossils worn, but may include unworn terrestrial forms.

11. Likely to be found in the vicinity of glacial till.

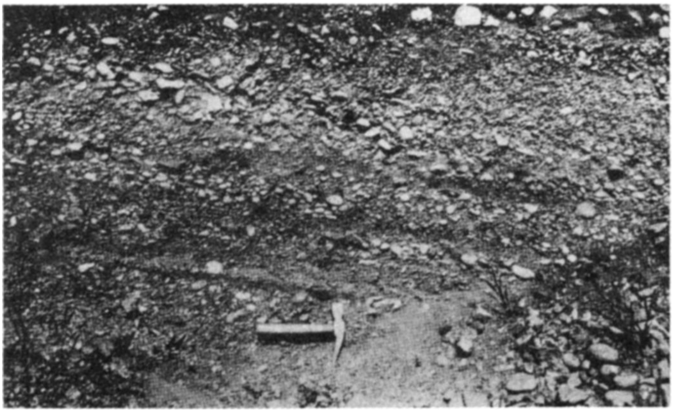

FIG. 8.—A fluvio-glacial deposit in Wisconsin (photograph by L. E. Wells).

Fluvio-glacial deposits bear all relations in position to glacial till. They lie over, under, or within the till, though they may also lie out beyond the till in the form of outwash plains or valley trains. Fluvio-glacial deposits are shown photographically in Fig. 8.

LACUSTRINE DEPOSITS (NEAR-SHORE PHASE)

In these deposits are the materials brought to lakes by streams, cut from the shores by waves, carried and deposited by feeble littoral currents, etc. The zone of deposition is one of frequently changing conditions, due to changes in volume of streams, strength of wind, direction of shore currents, shape of spits, bars, deltas, etc. These deposits may be distinguished by the following characters:

1. Material likely to be coarse.
2. High textural range (bowlders to silt).
3. Well sorted into lenses and pockets and arranged in linear areas.
4. Textural divisions grade out in all directions.
5. Fossils from running-water, surf-water, and still-water habitats.
6. Constituents well or poorly flattened.
7. Cross-bedded.
8. Special markings; ripple-, wave-, rill-marks, mud-cracks.
9. Rather abrupt variations in thickness.
10. Bedding planes dip in all directions, predominantly from shore.
11. Bedding planes dip at angles varying up to angle of rest for the materials (edges of deltas, ends of spits, etc.).
12. Distributed in narrow belt parallel with lake shore.

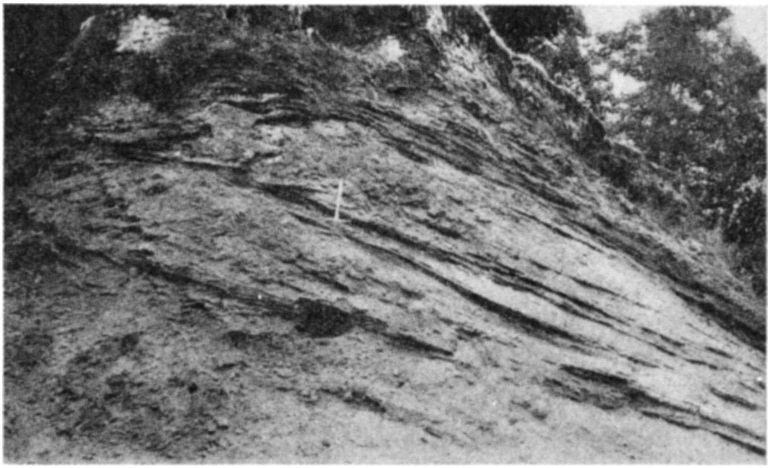

FIG. 9.—A near-shore phase of lacustrine deposit in Wisconsin.

Fig 9 shows some lacustrine sand and gravel exposed in the margin of the bottom of an extinct lake in Wisconsin.

LACUSTRINE DEPOSITS (STILL-WATER PHASE)

1. Material fine in texture.
2. Low textural range (sand to silt).
3. Well sorted into definite layers.
4. Rather uniform in thickness.
5. Beds likely to be finely laminated (in some cases 20 to the inch).
6. Distributed continuously over large or small areas, according to size of depositing lake.

7. Surrounded by near-shore lacustrine deposits.
8. Textural divisions grade into one another vertically, but not laterally.
9. Fossils of still-water types of life.
10. Bedding planes essentially horizontal.
11. May be ripple-marked.

Fig. 10 shows a section of laminated lake clays which were found less than half a mile from the section in Fig. 9. Fig. 10 illustrates the still-water phase of lacustrine deposits as contrasted with the near-shore phase deposited in the same lake. Another contrast of this sort may be seen in Figs. 14 and 15, *Jour. Geol.*, XIX, 724.

SHALLOW-WATER MARINE DEPOSITS

ZONE OF MAJOR AGITATION

1. In general coarse material.
2. Rather high textural range (bowlders to mud).
3. Sorted into lenses, pockets, irregular linear areas.
4. Contain marine fossils with possible mixture of land forms.
5. Distributed in rather narrow belt parallel with coast.
6. Different textural divisions grade out laterally and vertically.
7. Special markings; ripple-, rill-, wave-marks, mud-cracks.
8. Sorted texturally and to some extent mineralogically.
9. Considerable range in thickness within short distances.
10. Cross-bedded.
11. Constituents likely to be flattened.
12. Bedding planes dip in all directions, but chiefly from shore.
13. Bedding planes have dips varying up to angle of rest for the materials (edges of deltas, ends of spits, etc.).

By comparing these characters with those of the near-shore phase of the lacustrine deposits, these two sorts of deposits are found to have the same characters, with the exception of fossils and a slight difference in distribution. There would also be a difference in degree; that is, the marine deposits might contain coarser material, have a higher textural range, thicker textural divisions, etc. This type of sediment after cementation is illustrated in Fig. 11 which shows a section in the Potsdam sandstone at the Dells of the Wisconsin River near Kilbourn, Wis.

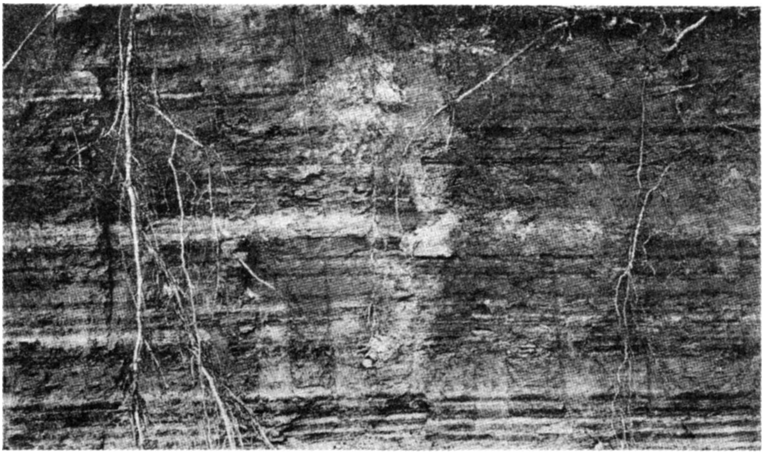

FIG. 10.—Some laminated lake clays deposited in the still water of the same lake which received the near-shore deposits of Fig. 9.

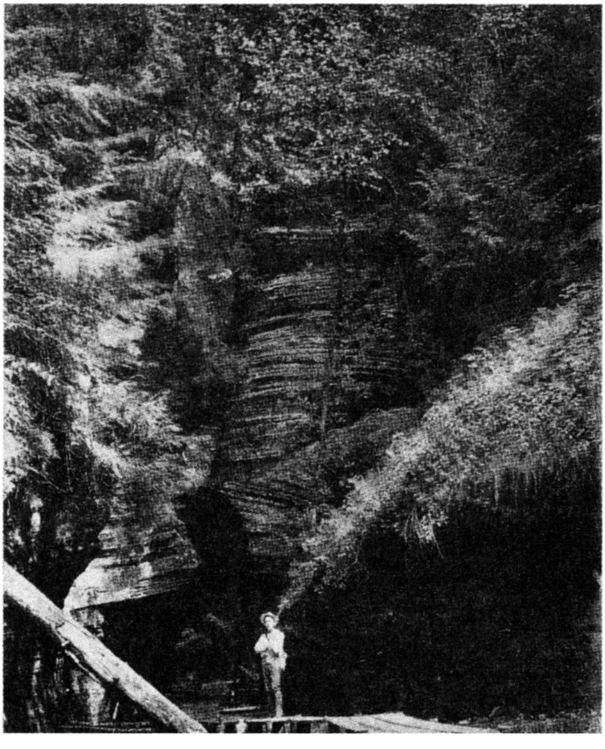

FIG. 11.—The Potsdam sandstone, a type of deposits in the sea in the zone of major agitation.

SHALLOW-WATER MARINE DEPOSITS

ZONE OF MINOR AGITATION

There is no great difference between these materials and the still-water lacustrine deposits, though there are differences in distribution, fossils, textural range, texture, etc. The list follows:

1. Average materials fine in texture.
2. Rather low textural range (sand to silt and limestone).
3. Sorted into definite continuous layers.

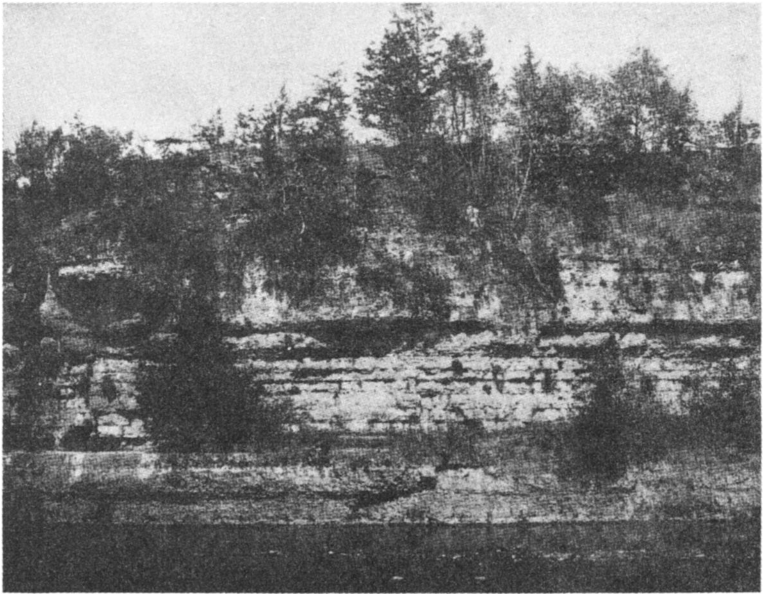

FIG. 12.—A section in the Galena dolomite of northwestern Illinois. This is a shallow-water marine deposit in the zone of minor agitation.

4. Marine fossils.
5. Distributed continuously over wide areas.
6. Does not vary greatly in thickness within short distances.
7. Special markings; ripple-marks (not rill- or wave-marks, or mud-cracks).
8. Include chemical and organic deposits.
9. Bedding planes essentially horizontal.

This deposit is well illustrated by the Galena dolomite of northwestern Illinois, which is shown in Fig. 12. All the essential

KEY TABLE FOR IDENTIFICATION OF VARIOUS CLASSES OF SEDIMENTS

	Eolian	Fluvial	Pluvial	Talus	Glacial Till
Texture...........	Fine	Variable	Coarse	Coarse	Variable
Textural range.....	Low	High	High	Medium	Very high
Stratification.......	Irregular beds and lenses	Lenses and pockets	Lacking	Lacking	None
Constitution.......	Homogeneous or heterogeneous	Heterogeneous	Fairly homogeneous	Homogeneous	Heterogeneous including foreign matter
Distribution......	Irregular areas, not continuous	In narrow, linear areas	Restricted, isolated areas	Restricted, isolated areas	Broad areas
Amount of dip......	Variable within limits (0–30°)	Variable within limits (0-18°)	....	....	....
Direction of dip....	In all directions	Diverge in one general direction	....	....	....
Thickness.........	Varies greatly in short distances	Decrease uniformly in one direction	Increases in one direction	Variable	Exceedingly variable
Shape of pieces.....	Rounded, pitted	Angular or rounded	Angular	Angular	Subangular, striated
Fossils............	Land forms suggesting aridity	Fresh-water and land forms (scarce)	Terrestrial forms, if any	....	Terrestrial or marine forms but worn
Characters not included above.....	May be ripple-marked	May include large bowlders	Found only near highlands	Very porous	Lie on unweathered, striated bed. Large bowlders

	Fluvio-glacial	Lacustrine (Near-Shore Phase)	Lacustrine (Still-Water Phase)	Shallow-Water Marine (Zone of Major Agitation)	Shallow-Water Marine (Zone of Minor Agitation)
Texture	Medium	Variable	Fine	Coarse	Fine
Textural range.....	Rather low	Rather high	Low	High	Low
Stratification	Lenses and pockets	Lenses, pockets, belts	Layered, laminated	Lenses, pockets, belts	Definite, continuous layers
Constitution........	Heterogeneous	....	....	Heterogeneous	Mechanical, chemical, and organic deposits
Distribution	In belts	Belts	Over more or less wide areas	Long, continuous belts	Continuous over wide areas
Amount of dip	Cross-beds may have high dips	Variable within limits	Essentially horizontal	Variable within limits	Essentially horizontal
Direction of dip....	Diverge in one direction	In all directions, chiefly from shore	....	In all directions, especially from shore	....
Thickness.........	Decrease in one direction	Variable	Uniform	Variable	Uniform
Shape of pieces.....	Roundness on subangularity	Flattened or rounded	....	Flattened or rounded	....
Fossils.............	Terrestrial, worn if marine	Fresh-water forms (running-, surf-, and still-water)	Fresh-water forms (still-water)	Marine, with possible land forms	Marine forms
Characters not included above.....	Occur near till	Cross-bedding, ripple-, wave-, rill-marks, mud-cracks	Laminae	Cross-bedding, ripple-, wave-, rill-marks, mud-cracks	Possible ripple-marks

characters have been retained even after cementation and partial metamorphism.

DEEP-WATER MARINE DEPOSITS

Deposits of the deep sea, that is, those materials laid in the sea beyond the edge of the continental shelf, are not here described, partly because their position of deposition makes their study in place almost impossible and partly because they are not commonly represented on the lands either in cemented or unconsolidated rocks. They are known, however, to consist of the finest terrigenous material, remains of pelagic life, submarine volcanic materials, atmospheric dust, extra-terrestrial materials, and the results of chemical alteration of the above-mentioned substances. Presumably most of it is finely divided, has a low textural range, and lies in horizontal strata. The fossils are doubtless pelagic in character.

An attempt is made to condense all the important characters in the foregoing lists into a single table which may be used as a key to the identification of the various common sediments.